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Abstract

Full Text

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GEOPHYSICS

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ON THE REGISTRATION OF THE POTENTIAL GRADIENT OF THE ELECTROTELLURIC FIELD AT CERTAIN DEPTHS OF LAKE BAIKAL

(Presented by Academician V. V. Shuleikin, 24 XII 1956)

Marine electric currents were discovered long ago (^1), but the regime of the electrotelluric field in bodies of water has still been studied only poorly. Usually, in studying natural electric currents in bodies of water, measurements were made either on the bottom of the body of water near the shore (^2), or in the surface layer of the water (^1-3). In order to study the regime of currents at different horizons, we organized simultaneous recording of variations of the potential gradient of the electrotelluric field at different depths of Lake Baikal.

Fig. 1. Simultaneous recording of short-period oscillations of the first kind on 19 III 1955 in Baikal:
a —at a depth of 5 m; *b* —1100 m

Receiving devices. The measuring installation consisted of a photogalvanograph and receiving lines submerged to various depths of Baikal. In the first period of observations (from 20 II to 1 IV 1955), the eastern receiving lines were submerged to depths of 5, 200, and 1100 m, and the northern ones to depths of 5 and 400 m. Registration of variations of the potential gradient was carried out simultaneously from two of these five lines. In the second period of measurements (from 15 III to 10 IV 1956), registration was carried out simultaneously from four lines of two ordinary cross-shaped installations lowered to depths of 200 and 700 m. All electrodes (lead plates with an area of 0.4 m^2) of lines of one direction were in one vertical plane. To connect the electrodes with

Fig. 2

Figure 2: Fig. 2

the photogalvanograph, PSM wire was used (employed in electrical prospecting work). The photogalvanograph was installed on a stand insulated from the floor in a specially built heated booth located on the ice of the lake near the settlement of Listvenichnoe. The galvanograph register provided drawing of the oscillographic paper at speeds of 4, 10, 20, and 90 cm/hr. At the same time a permanent telluric station operated at Zue (^4).

In the operation of both stations, the main attention was directed to the registration of short-period oscillations (s. p. o.) of the gradient.

Results of measurements

1. In Figs. 1 and 3 records are presented illustrating the character of the course of first-order s. p. o. (5) at depths of 5 and 1100 m. From a direct comparison of the curves in Fig. 1 it is found that all 137 s. p. o. registered during 53 min. at the surface of the lake were also observed at a depth of 1100 m. At the same time, the excitation of the corresponding oscillations at the surface of Baikal and at a depth of 1100 m occurs, to within the errors of reading, simultaneously; the periods of the corresponding oscillations at different depths are equal.

Fig. 2. Simultaneous recording of second-order s. p. o. on 9 III 1955 in Baikal: *a*—at a depth of 5 m; *b*—1100 m

A detailed comparison of more than 20,000 first-order s. p. o. from the materials of their simultaneous registration at different depths showed the identity of all oscillations and impulses, apart from an insignificant decrease in the amplitude of the s. p. o. with depth. The amplitude of the s. p. o. at a depth of 1100 m amounts to 93–99% of their amplitude at the surface of the lake (see Table 1).

Table 1

Comparison of amplitudes of corresponding s. p. o. at depths of 5 and 1100 m

Quantity	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13
Amplitudes (mV/km) of corresponding s. p. o. at depths	5 km	3.45	3.20	3.45	3.47	3.35	3.53	3.38	2.60	2.26	2.86	3.41	2.67	1.53
Amplitudes (mV/km) of corresponding s. p. o. at depths	1100 km	3.30	3.11	3.31	3.31	3.21	3.39	3.23	2.48	2.15	2.73	3.26	2.54	1.46
Ratio of amplitudes (%)		95.6	97.2	95.9	95.3	95.8	96.0	95.5	95.4	95.1	95.7	95.6	95.1	95.3
Amplitudes (mV/km) of corresponding s. p. o. at depths	5 km	1.76	2.42	2.12	1.52	1.99	1.54	1.52	3.39	3.25	2.86	2.33	3.10	

Fig. 3

Figure 3: Fig. 3

Quantity	Depth	1	2	3	4	5	6	7	8	9	10	11	12	13
Amplitudes (mV/km) of corresponding s. p. o. at depths	1100 m	1.65	2.28	2.00	1.46	1.90	1.48	1.43	3.24	3.09	2.71	2.20	2.93	
Ratio of amplitudes (%)		93.7	94.2	94.3	96.0	95.4	96.1	94.0	95.5	95.0	94.7	94.4	94.5	

The good insulation of the wires used in the measurements excludes the possibility of a decrease in the amplitude of the s. p. o. in the lower measuring lines due to insulation.

The winter vertical distribution of temperature in Baikal (6) may cause a certain increase in the resistance of the upper layer of lake water down to a depth of 100–150 m. But comparison of the amplitudes of s. p. o. at depths of 200 and 1100 m also confirms their attenuation with depth, although the temperature difference of these layers is only 0.3°.

The decrease in resistance with depth due to an increase in the amount of substances dissolved in the lake (6) is evidently very small, since it could not be detected by laboratory measurements of the resistance of water samples taken from different depths.

Fig. 3. Simultaneous recording of pulsations of the first kind on 13 III 1955: *a* –in Zue; *b* –in Baikal at a depth of 5 m; *c* –in Baikal at a depth of 1100 m. To facilitate comparison, the corresponding pulsations in Zue and in Baikal are designated by identical numbers.

The conductivity of the waters of Baikal is on average 6×10^4 electrostatic units. With this conductivity, the absorption of pulsations by the waters of Baikal is characterized by the values given in Table 2. The data in the table were calculated from the known formula (7) for determining the absorbing influence of a medium on a variable electromagnetic field.

Table 2

Frequency of pulsations, f in $\sec^{-1}$	1/10	1/30	1/30	1/40	1/50	1/60	1/5000
Amplitude at a depth of 1000 m as % of the amplitude at the surface	95.0	96.5	97.0	97.4	97.7	97.9	99.7

Thus, the decrease in the amplitude of pulsations with depth is caused, apparently, mainly by their absorption by the waters of Baikal. Therefore this phenomenon (the decrease with depth of the amplitude of pulsations) may be regarded as a new confirmation of the well-known assumption that the sources of pulsations are located not inside the Earth, but outside it.

2. As observations have shown, pulsations of the second kind (8) at the surface of Baikal and at a depth of 1100 m are excited simultaneously (within the accuracy of the sweep), the periods of the corresponding oscillations at different depths coincide and lie in the interval 35–55 sec, and the amplitude decreases with depth (Fig. 2).

At the measured depths, bay-like disturbances of the electrotelluric field are likewise excited simultaneously; the periods of corresponding bays at different depths are equal and lie in the interval 15–70 min. The discrepancy in the magnitude of the amplitudes reaches 11% in one direction and the other for corresponding bays at depths of 5 and 1100 m, and 7% for bays at depths of 200 and 1100 m; moreover, a decrease in the amplitude discrepancy is found as the duration of the bays decreases. The difference in the amplitudes of

Figure 4

Figure 4: Figure 4

corresponding bays is apparently caused by the influence of extraneous processes (^{9}).

Fig. 4. Distribution of k. p. k. of the first (*a*) and second (*b*) kind

3. A detailed comparison of the regime of the electrotelluric field in Baikal and on land (at Zue—80 km from Baikal) showed simultaneous excitation, complete agreement in the parallelism of the course (but not in the magnitude of the amplitude), and equality of the period of corresponding k. p. k. of the first kind at Zue and in Baikal (Fig. 3).

Within the accuracy of the measurements, k. p. k. of the second kind and bay-like disturbances are also excited simultaneously in Baikal and at Zue, have a parallel course and the same period.

The amplitudes of k. p. k. of the first and second kind depend on the electrical conductivity of the medium at the observation points; the amplitude of bays also depends on the electrical conductivity of the medium, but in this case, as already noted, the influence of extraneous processes takes place.

4. The distribution of the frequency of occurrence during the course of a day of clearly expressed k. p. k. of the first kind and of tsugs (k. p. k. of the second kind) is given in Fig. 4. When considering k. p. k. of the first kind as a whole, and not only distinctly expressed cases, it is found that, having reached their greatest development in the interval 3-10 hours, they gradually die away by 19-20 hours Universal Time; in this latter interval they have either the least development or are completely absent (rarely).

The greatest recurrence of bays is observed during the night hours; sometimes the bays are accompanied by tsugs (Table 3).

Table 3

Daily variation in the recurrence of bay-like disturbances (based on material for 40 days)

Intervals of Universal Time, hours	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24
Number of bays, %	1	1	4	8	17	29	26	14
Number of bays with tsugs, %	–	–	–	1	1	12	5	–

In conclusion, I take this opportunity to express my gratitude to A. I. Tyutrin, who made the photogalvanograph, and to N. P. Ladeishchikov for support in organizing the observations.

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Note: Figure translations are in progress. See original paper for figures.